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SCIENCE EDUCATION IN THE JUNIOR COLLEGE, PROBLEMS AND PRACTICES.

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NATIONAL SCIENCE TEACHERS ASSN., WASHINGTON, D.C.

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MAJOR ADDRESSES AND SUMMARIES OF GROUP ACTIVITIES FROM FOUR CONFERENCES ON TEACHING SCIENCE IN THE JUNIOR COLLEGE ARE PRESENTED. THE PRESENT STATUS OF JUNIOR COLLEGE SCIENCE IS EXAMINED AND SUGGESTIONS ARE MADE FOR IMPROVEMENT. NEW APPROACHES TO PHYSICAL SCIENCE AND BIOLOGICAL ASPECTS OF THE SPACE PROGRAM ARE CONSIDERED. WORKING GROUP REPORTS INCLUDE INFORMATION RELATED TO GENERAL EDUCATION SCIENCE, TECHNICAL EDUCATION, BIOLOGY AND PHYSICAL SCIENCE LABORATORY PROGRAMS, STUDENT BACKGROUND, AND TRANSFER STUDENTS. THIS DOCUMENT IS ALSO AVAILABLE FROM THE NATIONAL SCIENCE TEACHERS ASSOCIATION, 1201 SIXTEENTH ST., N.W., WASHINGTON, D.C. 20036, FOR \$1.00. (AG)

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# SCIENCE EDUCATION IN THE JUNIOR COLLEGE



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**Albert F. Eiss, Editor**

**A Report of Four Conferences on Junior College Science Teaching**

**Commission on the Education of Teachers of Science  
of the**

**National Science Teachers Association  
1201 Sixteenth Street, N. W.  
Washington, D. C. 20036**

The Commission on the Education of Teachers of Science of the National Science Teachers Association wishes to express its appreciation to Mary Hawkins for final editing of the manuscript, to Esther Patterson for typing it and arranging for publication, and to the other members of the NSTA staff who assisted in producing this publication.

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## **F-O-R-E-W-O-R-D**

This publication has been prepared from materials obtained at four conferences on junior college science teaching held during the 1965-66 academic year. Several hundred teachers attended these conferences. Their enthusiasm for the speakers and for the results of discussion groups has encouraged us to publish the material. The National Science Teachers Association wishes to thank the many science instructors who assisted in conducting the meetings and in preparing the reports of the work sessions. Particular thanks goes to the many participants who, with their enthusiastic response and critical discussion, made these reports possible.

**Robert H. Carleton  
Executive Secretary  
National Science Teachers Association**

## I-N-T-R-O-D-U-C-T-I-O-N

During the 1965-66 academic year, the National Science Teachers Association's Commission on the Education of Teachers of Science held four conferences on science education in junior colleges. One was held during the NSTA regional meeting in Detroit, Michigan, in cooperation with the Michigan Academy of Arts, Sciences, and Letters. Another was held during the NSTA regional meeting in Tucson, Arizona, in cooperation with the Arizona Academy of Science. The next was held during the AAAS annual meeting in Berkeley, California. The fourth and last session was an invitational meeting held in Philadelphia, Pennsylvania, in cooperation with the Pennsylvania Academy of Science.

The final meeting was designed as a working session to review and coordinate the work of the previous meetings, and to develop suggestions that would assist junior college science instructors in revising the science curriculum.

The publication consists of two parts. Part I presents some of the presentations and panel discussions that were particularly pertinent to problems of junior colleges. Part II consists of the summaries prepared by the working groups and the conclusions that may be drawn from them.

This booklet is published as a service to the many junior college science instructors throughout the country who are dissatisfied with their present courses and wish to introduce new content, new ideas, and new teaching techniques into their curriculum. A publication of this sort can never equal the value of actual participation in such a conference, but it may be of assistance to those who were unable to attend.

Albert F. Eiss  
Associate Executive Secretary  
National Science Teachers Association

**PART I - MAIN ADDRESSES**



## THE CHALLENGE TO SCIENCE EDUCATORS

J. O. Luck  
Head, Education and Training  
Murray Hill (New Jersey) Laboratory  
Bell Telephone Company

In preparation for my role as keynote speaker, I reviewed the materials sent to me as background information for this conference. As I studied the information, it became increasingly clear that the participants in this workshop are well informed. You have been deluged with data concerning the number of students enrolled in junior colleges, the growth of the junior college movement, the growth of science education within the junior colleges, the number of terminal students versus the number who continue on to four-year institutions, and so on. It thus appears unnecessary for me to present this wealth of data to you once more. It seems more appropriate that I appear here not with the intention of informing you but rather with the intention of reminding you of some facets of the problems now facing science educators and science education in the junior college in particular. But to remind you of these facets and leave you seems inappropriate unless I also remind you of a methodology or a procedure by which you may best come to grips with the problems you have identified and upon which you will work during the next two days.

Let me start by quoting from the report of January 11, 1962 of the President's Advisory Committee on Labor Management Policy. "Our purpose then is to seek the course of action which will encourage essential progress in the form of automation and technological change, while meeting at the same time the social consequences such change creates." First, let us note that this significant statement is from a labor-management group and not from a science-engineering group. The statement seems to remind that the leadership of this nation and, in fact, we the people are encouraging change. This is being done by increasing the investment in basic research and in development and by increasing the reservoir of manpower trained to participate in the research and development processes. The financing, as you know, is from private and from public sources.

The increasing support of basic research and the availability of more and more qualified people to participate in the search effort assures us of an increase in the rate at which knowledge is developed. Here lies the root of one of the most serious problems facing science educators. How can you organize yourselves to assimilate the new knowledge quickly and equally quickly develop new curricula and courses so that you offer an educational program in tune with the times--an educational program that will prepare young men and women to participate effectively in today's society and to cope with at least today's problems? Your problem in the junior colleges in this regard is much more difficult than the same problem faced by the graduate schools even faced by bachelor's degree granting institutions. It seems to me that each of the work sessions you have identified for this workshop must consider this general question.

In my phrasing of the question, I alluded to the need to develop new courses. In this era of rapid growth in our scientific knowledge and in our technological development, we do develop new courses. In fact, we proliferate courses in narrow specializations. What are needed, however, are courses that synthesize the knowledge within each broad scientific area. Such courses are needed in order to utilize effectively the time span available, for while the body of knowledge increases, there is no indication that the time span in which the knowledge must be disseminated and absorbed will substantially change.

Not only should we seek to develop courses that synthesize the knowledge within a field such as physics or chemistry, but we should also seek to develop unified courses in science for general education as well as for the preparation of transfer students who will specialize in physics, chemistry, or biology. Such unified courses which present the fundamental principles of physics, chemistry, and biology are difficult to develop, organize, and teach. Certainly not all that is now taught in biology, chemistry, and physics can be or should be included. But reasonable and knowledgeable minds can identify the essential, underlying principles, and the fundamental problems as the starting point in the development of such courses. I may be asking for too much in suggesting that biology be included at this time in such a unified course, but certainly a course containing the necessary physics and chemistry can be developed and taught.

Let me go back at this point to the Committee on Labor Management Policy where it states, "...while meeting at the same time the social consequences such change creates." As educators, what are our responsibilities in this area? Do we identify for our students some of the fundamental technological problems facing our society? These include air and water pollution, a reliable potable water supply, traffic congestion, increasing agricultural productivity, and industrial productivity. Do we identify for them the fact that current technology can solve the problems of air and water pollution, of assuring a potable water supply, and of traffic congestion? Do we discuss the legal, social, and economic factors that impede the technical solutions?

I doubt if we should include such questions in discussion within our science courses, but we should make certain that they are included in the general curricula of courses taken by our students. We know what the technological problems are, and we know the available technical solutions. We must make certain our fellow educators in the social sciences are informed and are able and willing to discuss these technological problems with our students. One possible aid in developing such understanding on the part of our fellow educators in the social sciences may be summer workshops in current problems in our society and their possible technical solutions. These workshops should be conducted by the leaders in the scientific and engineering committees.

As science educators, we tend to avoid our responsibilities for the development of courses in the history and in the philosophy of science. It seems to me that the general student

ains a great deal from such courses when they are well taught, well organized, and up to date.

As an alternative to such separate courses in the history and in the philosophy of science, the present classic history and philosophy courses can be revised to include a fundamental grounding in the impact of scientific development and scientific thought on our history and our philosophy. Once again we may find a need to give some thought to developing programs for the re-education of our colleagues in the social sciences.

As science educators, automation is not our primary concern. However, it is a mistake to ignore in the development of our courses this very important field. We can help prepare students for full participation in this automated society by encouraging data processing and programming instruction wherever feasible. No student should be leaving junior college without being able to utilize a computer as an aid in his work. It will not be long before all employees, starting with secretary and clerk and going right up the line will need to be able to work with these data-processing machines.

Thus the challenges to science educators in the junior college movement are many and diverse. They include retaining one's competence, developing new courses, instilling a sense of social responsibility in our students, helping our fellow educators in other fields acquire the scientific knowledge and insight necessary to make their courses more meaningful in this technological age.

I should like now to suggest a procedure for each of the workshop groups. Make certain that you identify the goals for our discussion. What is the problem to which you will address yourselves? Next, make certain that you have several alternative solutions and that you develop criteria by which you will evaluate the alternatives. These criteria would include boundary conditions such as cost, time, availability of competent staff, etc. Finally, select the alternatives deemed most desirable. In brief, don't just have a bull session. You have a real opportunity to make a contribution to science education. Make the most of it through well organized, disciplined considerations of specific problems.

## MEETING THE CHALLENGE I

Rudolph L. Heider  
Associate Professor, Chemistry  
Meramec Community College, Kirkwood, Missouri

Just what is "The Challenge"? For those of us in junior college work it is how to educate large numbers of students of widely varied backgrounds, interests, and motivation to achieve independent and reasoned judgment in the sciences. I will direct my remarks to the training of the professional scientist or engineer and of the scientific technician. My training and entire career have been in chemical engineering and chemistry, with over 20 years' varied industrial experience in a large chemical corporation. Needless to say, I prefer to relate my thoughts to this industry as a prototype, since many of its technical manpower and training problems do not differ much from those of other highly technical industries.

Education is now--or soon will be--the largest "business" or enterprise in the United States. Further, the product of our schools must be able to cope with the world as it will be 10 to 20 years in the future. Long-range planning is now an important staff function in any large corporation--so it must also be in education.

For how can we educate youngsters for tomorrow unless we have a fairly good idea of what tomorrow will bring? Many educators are grappling with this problem. You may have read Dr. R. M. Hutchins' recent article in The Saturday Review entitled "Are We Educating Our Children for the Wrong Future?" I believe this might be better stated, "Are We Wrongly Educating our Children for the Future?" I certainly hope we have sufficient control of our own destiny to make the future "right"!

Let's gaze into the crystal ball to have a look at the future. First, 90 percent of all the scientists that have ever lived on earth are now alive and generating scientific information at jet speed. Second, the revolution due to automation has just begun to move out of its infancy. Third, because of the population explosion, man must eventually form a world government wherein present independent governments may become states of a new world organization. If this does not happen, it is highly probable that we are headed for another long period of dark ages wherein civilization, as we know it today, is barely able to survive.

One aspect of this complicated picture is, however, becoming quite clear, i.e., new technology resulting from automation over a reasonable number of years which were highly uncomfortable because of the extremely high rates of unemployment--will employ more people than are displaced; but those employed will have to be highly skilled and highly trained.

Look at it this way: The first revolution was the Industrial Revolution which led to relieving man of most of the



difficult, back-breaking physical labor. You will recall that the prophets of doom predicted horrible consequences of man's use of machines. This was because it is so difficult to visualize the growth of brand-new products and industries based on today's outlook. For example, consider the number of people employed and the technical skills needed in providing us with electric lights, compared with that needed for kerosene lamps.

The second revolution is now beginning to pick up momentum, i.e., the impact of automation which will relieve man of a great deal of mental work. Again, we shall suffer a period of disorientation until new activities will be uncovered by man. Note that I stated "activities" and not "production or new products." The only relationship we now understand is between production and employment. If, however, 10 to 20 percent of the population will be able to produce all the material goods required by man, then it is obvious that this relationship will be severed. The social, political, economic, and educational aspects of this dissolution are staggering, and more than a little frightening, as viewed in October 1965. Therefore, it is highly probable that our students will find themselves without work as defined by today's thinking. Dr. Hutchins has stated, and I agree, that in any country that has a fast moving technology and a highly mobile population, specific education directed at jobs is bound to be ineffective.

To put it bluntly, we cannot much longer regard education as a means of making individuals more efficient in the art of production. We must become more concerned with making individuals badly educated persons.

One other aspect of science education is also coming into focus, namely, that education will be a womb-to-tomb proposition. The junior colleges will be but one line--we hope an important one--in the total science education of an individual. Again, this is a reflection of the tremendous output of scientific information. It is now estimated that, without further education, a scientist or engineer will be obsolete in less than 10 years. Whatever activity the modern scientist or engineer is engaged in, it will be necessary for him to devote up to 50 percent of his time on the job to the task of continuing to keep abreast of this flood of information. The eschatology of this trend is staggering! Perhaps one answer lies in knowing much more about the brain and nervous system so that we might transfer electronically taped information in a computer directly into the brain of an individual, essentially cutting a "tape" in the brain from a master tape on a computer. Does this appeal to you as an easy way to teach science 101?

Let's return to today--Fall 1965--and think about what we are now doing in relation to the future as we see it. What, then, is the nub of our problems in education? I believe it is that we know so tragically little about the learning process, about creativity, and about motivation. In my opinion, research in these areas should assume an importance equal to that of a missile program. We have become highly efficient in a large

number of areas--particularly warfare--but what revolutionary developments have occurred in educational methods and learning processes that would hold a candle to the development of atomic physics, for example? Recall that education is--or soon will be--our largest enterprise.

Obviously, to protect this investment, we need to expend effort on basic research. The chemical industry normally spends from 3 to 5 percent of its investment per year for research. By such a yardstick the educational industry, if I may call it such, is spending an unbelievably small amount for basic research: net effect--little or no progress! We have been proud of the growth of the sciences over the past 50 years. Yet, after being away from the college laboratory for almost 25 years, I am shocked to find that the laboratories of today are almost a carbon copy of those I left 25 years ago. To be sure, we now make good use of plastics, pastel colors, and modern design but, educationally, there has been little change!

What might we do to increase the efficiency of learning? What new ideas and methods are already here that might increase the student's learning efficiency? Here I am referring to both the quantity and the quality of the learning process. The S. R. I Report\* lists some of the trends in education as compiled by Harold B. Gores, President of the Educational Facilities Laboratories. These trends are for public school education but certainly are also pertinent to junior colleges. These changes affect every facet of education: physical facilities, teachers, students, but most pronouncedly a different attitude towards teaching.

We who are teaching science in junior colleges have an excellent opportunity to incorporate many new ideas into our building programs, since the junior college movement has now begun to grow so rapidly throughout the nation. Here is indeed a challenge to our imagination, ideas, foresight, and courage. Let us hope that we build structures that are new educationally, and not based on obsolete college classroom and laboratory design that many architects seem to continue to build. Another challenge facing us is the courage to work unswervingly and with faith on newer concepts of teaching, at the guaranteed risk of being called a "faddist" by colleagues and something much worse by the general public--at the risk of failure.

Let us set an example to our fellow teachers by being extremely cautious against closing our minds to new and different approaches and assist wherever we can to give these infant ideas a fair chance for survival and testing. There never was a process or idea that could not be improved. Certainly, educational research is bound to lead to improvements.

I have a strong feeling that our friends and the general public will judge the junior college movement by the quality of our instruction and by our genuine concern for the individual student. We will win no brass medals for our excellence in scientific

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\*Stanford Research Institute, Menlo Park, California

search; nevertheless, we must pursue a vigorous program of educational research--and will be expected to do so--or fade into the background of mediocrity and, so, disappoint the public who expected much from us.

Turning now to more immediate problems, we have the task of educating the transfer student for two years in the junior college and essentially completing the training of the two-year technician. The transfer student is really the simpler problem. To a large extent, we are tied to the four-year colleges because of the need to coordinate our curricula with theirs. However, considering chemistry and physics, I am somewhat concerned about the trend to give all high school students the CHEM Study, CBA, or PSSC approaches. The high schools may be neglecting some of the basic, so-called descriptive matter too soon in their eagerness to teach principles. In my day, every young, aspiring chemist had the opportunity to play with a Chemcraft chemistry set, as well as carry out experiments on making  $H_2$ ,  $O_2$ ,  $Cl_2$ , acetylene, and a lot of other materials (including black gunpowder) that youths today merely read about and seldom get to see, taste, smell, and feel. Too early, an introduction into principles has the effect of learning about a highly abstract science. I would much prefer a first exposure to chemistry to be qualitative and highly descriptive. College chemistry could then stress principles, which certainly must be taught. But my objection is to principles only without having first "tasted" chemistry.

I have organized my chemistry course for science majors largely on principles, bringing in descriptive work whenever possible; nevertheless, the tacit understanding is that the student has been earlier exposed to having "tasted" chemistry. We are this year for the first time experimenting with a terminal chemistry course for nonscience majors that attempts to educate the student to understand current problems of society involving chemistry, e.g., air and water pollution, radioactive fallout, food and fertilizer problems, and the like. I hope that our course will make our graduates much better informed citizens and more able to contribute constructively toward solving these pressing issues.

Scientists are frequently criticized--and I believe rightly so--for not taking more active part in society's problems. Here is another challenge we can grapple with! Do we teach only "principles" with a complete disregard of the despoliation of our earth's atmosphere, allowing our students to be educated by TV advertising and by publications of vested interests?

Finally, let's look at the two-year technology courses. Here we really do get into a mare's nest! Let me repeat: My comments will be pertinent to the field in which I have spent my entire career--chemistry and chemical engineering. Thirty-five to forty years ago attending a college was, for the most part, a function of wealth in the family. Essentially all who had the necessary financial assistance were able to attend one school or another. Those with limited resources might attend a two-year college to become a technologist. This permitted many very able

students--albeit poor--to get a start in the industry. Then came the tremendous growth of the Land-Grant Colleges, especially in the Middle West. This opened doors of opportunity to many more students. Again, however, standards were not too vigorous and usually there were more engineers available than job opportunities. Perusal of statistics will show a large number of trained chemists and engineers who became disenchanted with the lack of jobs or the menial nature of their work, and so changed their field of activity.

Thus, as a result of wider educational opportunities--particularly as compared to the European countries, an ample supply of engineers was generated by the standard four-year colleges. Some of these engineers were very well trained; others, less so. On the job, natural selection soon took place, resulting in some engineers doing technicians' or technologists' work. With an ample supply of graduates in science and engineering, U. S. industry was oriented to use these graduates, with only a poor understanding of what the two-year technologist was or what his contribution could be. As a result, up to the present there has been an amazingly slow growth in full-time enrollments in technical institutes as compared to total college enrollments over the same years. To this day, there is still a severe lack of understanding on the part of industry of what a two-year technologist might do for them, primarily because industry is concerned about their long-term potential and their impact on labor unions.

Government statistics have in the past, and again more recently, stated that "the already short supply of engineers will be intensified in the near future." Many professional engineering societies will dispute this claim. I wonder if one factor has not been overlooked in the government statistics, i.e., the trend to further education of graduate working engineers which, of course, is a method of increasing their efficiency. There is much that can be done along these lines, and I am most pleased to see the chemical industry in St. Louis working hand-in-glove with local universities and colleges to help upgrade their employees. Moves in this direction will curtail the predicted shortage of engineers.

Government statistics also, I suspect, are based on the need for technicians, assuming some arbitrary ratio of from two to four technicians per engineer. I would like to note that such a ratio has never been attained in the United States and would require a considerable difference in attitude on the part of industry especially since we now have about one technician per every two engineers.

The challenge in the technician area is to sort out with industry exactly what an engineer is, what his training should be and what a technologist is and what his education should be. We must be careful that we don't tool-up to produce a product that will not be bought by industry.

I strongly urge that we educate these engineering technology and industrial technology students, recognizing that they are likely to be in the 50th to the 20th percentile on the School and College Aptitude Test (SCAT), along the same lines as we do



our-year engineering students, only at a lower level--a level where these students can achieve success. There should be a spectrum of engineering abilities from the PhD down to the technologist or technician, but not a basic difference in their education. Because the technologist cannot do differential equations does not mean we teach him how to operate a "black box" to do analytical or production control work. Industry can do this much better than we can; furthermore, we are apt to be teaching the student how to use "black box 1" when the science has progressed to that industry is working on "black box 3." If it is true that in the future we will need to change the nature of our jobs about once to five times during a career, all the more reason to educate the two-year technologist along general lines stressing principles on which he can continue to build. Again, job-oriented engineering education in colleges and institutes is meaningless and an economic waste!

Concluding, we in junior college science teaching must be ready to meet the challenge of the 1970-1980's by:

Learning how best to educate vast numbers of students of widely differing backgrounds; especially to find meaningful ways to help the less gifted student achieve his maximum potential.

Since we will not be judged by our scientific research but rather by the skill and excellence of our teaching, we must continually look for new ideas in education and keep an open-mindedness toward testing and using any procedures that have promise toward increasing the efficiency of learning. We shall need to do educational research.

We need to work more closely with industry and the scientific and engineering societies to develop a meaningful course of study for the less gifted but scientifically oriented student in our two-year technology programs.

Finally, we cannot much longer look at education as a means of making individuals more efficient in the art of production. We are forced to become concerned with making all individuals broadly educated persons, each to his maximum potential.

## MEETING THE CHALLENGE II

Robert J. Hannelly  
President

Maricopa County (Arizona) Junior College District

First and foremost, I should like to go on record to say that the junior college science teachers in Arizona are doing a creditable job.

As I considered the subject assigned to me, i.e., "Meeting the Challenge," I concluded that I must pluralize it into "Meeting the Challenges." Furthermore, I deem it necessary to recognize or state what the challenges are before making suggestions as to how to meet them.

Science teaching cannot escape the general challenges to all educational endeavor. Among these general challenges are the knowledge and population explosions. Challenges more germane to science teaching in the junior college are: traditional methods, the need for all citizens to know more about science, the exceptionally good science teaching in some high schools, and the maintenance of quality with quantity.

Let us first consider the knowledge explosion. There is now available a plethora of textbooks, periodicals, paperbacks, films, and canned knowledge. The \$195 billion knowledge industry is growing twice as fast as the economy. The production of knowledge doubles every ten years, and there is 100 times as much to know as in 1900. By the year A.D. 2000, there will be more than 1000 times as much knowledge of all kinds to record, to sift, to store, to teach, and, hopefully, to use.

Technological knowledge is exploding also. There are 100 times as many chemists as in 1900. Ninety percent of all the scientists that ever lived are alive today. Dr. Norman Harris states that there are about 100 titles of jobs and professions in the medical field. More than 780 periodicals are published. An IBM ring of ten data cells can store 400,000,000 items, any one of which can be retrieved in a fraction of a second. Sophisticated hardware such as the F5, the IBM 360, and Gemini VI require new knowledge and vocabulary.

No less dramatic is the population explosion. In 1900, 4 percent of the college age youth attended college. Now it is 30 percent. In 1900, 6 percent of the nation's 17-year-olds graduated from high school. Now the figure is 71 percent.

President Lee A. DuBridge, of the California Institute of Technology, says "We are in deep trouble." But he adds, it is not the fault of the schools. He says further, "We are expecting too much of our schools and too fast."

Higher education in the United States will add more students in the next five years than were enrolled in 1954. The average size of colleges increased 55 percent between 1953 and 1960 and

will increase another 50 percent in the next five years.

Meeting the challenges of the knowledge and population explosions is not the sole responsibility of the junior college science teachers, but it does complicate their problems. The whole nation, including the rank and file of the citizenry, must accept these great challenges.

Now, I should like to proceed to matters for which science teachers may be able to accept more responsibility. Take tradition, for example. To particularize, take traditional method and content in science. Bold innovations have already been made, but has enough been done to select the most significant concepts, facts, and experiments to be taught or performed? What scientific knowledge is of most worth? Next week's scientific discovery may make last week's textbook obsolete.

What is the best method to teach physics, chemistry, or biology? Is it in fact lecture and laboratory? If so, is the ratio of half and half sound? To what extent should we use closed-circuit television or programmed materials? How can we individualize instruction when there are so many students? It may be true that science teachers are so busy that they do not have the time to investigate these questions and others for which they would like to know the answers.

Science teachers need help in research. Educational analysis by non-college agencies is gaining in volume and acceptance.

There is a serious omission when we speak only of improving content and method in the teaching of junior college science. It is the student. Too long we have ignored research about him. For example, how does he learn? How can he be motivated? Does he have to have a certain minimum IQ in order to learn college science? We have no substantial research on human characteristics of the junior college student. Sporadic studies have been made. When I heard that Leland Medsker was making a full-scale investigation of this matter at Berkeley, I wrote for a copy of his findings. He said it wasn't ready yet, and that was two years ago.

In order to meet the challenge of tradition, science teachers in the community junior college can insist that scientific analysis be applied to the problems in content, method, and student characteristics. This emphasis should come easily to the chief expositors and promulgators of the scientific method on the junior college faculties.

Next, let us discuss briefly the tremendous need for the average citizen to acquire more scientific knowledge for life in the future. Here again, we may be referring to a national problem. Former Commissioner of Education, Francis Keppel, has said, "Education is too important to be left solely to educators."

Yesterday's education no longer suffices for tomorrow's needs. Secretary of Labor Wirtz points out that the machine now has a high school education in the sense that it can do most of

the jobs a high school graduate can do. So the machine will get the jobs, because it works for a lower wage. A junior college education is necessary to compete with the machine.

For the sake of simplicity, let us divide junior college students into three categories: the upper 25 percent who go into professions, managerial, or high-level service jobs; the middle 50 percent or the average student; and the lowest 25 percent, the less able students. The top 25 percent includes students who will become physicians, dentists, engineers, and science teachers. All of these will be well grounded in science. Learning science is relatively easy for them. But also included in the top 25 percent are the students who become lawyers, managers, business executives, and English teachers. To what extent are we providing the science education that all of these will certainly need to function intelligently in the next generation?

Now, let us comment about the lowest 25 percent of the students. Learning science is difficult for them. Certainly, the standard courses in chemistry, physics, biology, and mathematics are generally beyond their comprehension. Still, there is a lingering question as to whether we owe to them the opportunity for them to try to learn some simplified, basic fundamentals in science. They are much above the average of the general population. They will vote, conduct business, and support the community in the future.

Now we come to the \$64 question. What should we do for the middle 50 percent of the students? They will constitute the warp and the woof of our society. Are the courses we now give suited to their abilities and future needs? After taking our regulation courses in science, could these students write a coherent page on "What is atomic fission?" or "How does solid fuel give power?" or "What really is soda water?" or "Exactly what happens when water freezes into ice?"

Is general science the answer? Should there be several levels and kinds of courses for this large group? Most of them will never enter scientific occupations. Here we are talking about the average college students. These are good and substantial people. Furthermore, there are many of them.

What kind of a science program does the college and the community, state, and nation it represents owe to these substantial citizens? In my view it owes its best effort, research, and instructional standards. They are capable of learning a great deal of science, and they will need it.

There is another serious problem about the middle 50 percent category, and that is "Which requirements should the college set up for them?" They can't learn science in college if they avoid it. I would hope that the future program for this group would be so attractive that students would be eager to participate in it. I believe it can be so constructed and offered.

Now just a final word about meeting the challenge in junior college science teaching: We can question the obvious and

traditional in content, method, and student characteristics. We can experiment with these variables or insist that experimentation should be performed. We can exert every effort to make sure that the middle 50 percent has a required, solid program of quality. We can accelerate brilliant high school students. Last, but not least, we can continue to expand our own scientific knowledge and teaching techniques by formal and informal study.



## MANPOWER, MONEY, AND MOLECULES

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Biology education today is influenced by important changes in three areas--manpower, money, and molecules. I am referring to (1) the supply, training, and functioning of teachers, (2) the influx of money for improving teaching, for research, and for support of students, and (3) the influence of the vast expansion of our knowledge of molecular mechanisms in life processes.

### The Teacher

A great deal can be said about recent improvements in textbooks, laboratory experiments, teaching aids such as films and television, curricula and the like; but all of these depend for their success on the teacher. The quality of teaching is determined ultimately, not by the paraphernalia, but by the personal qualities of the teacher. He must first know his subject, but he must also be aware that he exemplifies intellectual virtues and very often moral values and personal tastes.

The general awareness of this truism has led to more rigorous training and greater selectivity for teaching in biology and to more numerous opportunities for additional training and upgrading. I consider research participation to be an important activity in this category; teachers concerned primarily with undergraduate education should be given every opportunity to participate in research projects.

### The Resources

Research projects, summer and academic year institutes, experimental courses and programs require money. Apparently this money will be forthcoming through expanded federal programs, including the Higher Education Act. Vast sums for education will be spent in the next five years unwisely unless we make our needs known. Students will benefit not only from the added resources for the institutions, but also from increased availability of financial aids. Another GI bill will probably be passed to add to this subsidy.

### The New Biology

The third trend which has generated so many new approaches in biology education is the molecular revolution. The whole area of molecular biology is either deified or denigrated more often than it is put in its proper perspective. Spectacular breakthroughs in our understanding of a number of very crucial life processes have come from the application of the techniques and theories of the physical sciences to biology, but it is the achievements, not the applications of physical methods and principles that are new. When modern chemistry was brand new, 150 years ago, it was being applied to biological problems. The climate in the life sciences in the

past 20 years has been ripe for a new synthesis, back from an educational, administrative, and investigational fragmentation that had taken place over the years. The molecular trend required this atmosphere for its success and served in turn to reinforce the movement toward the reductive, integrative, comparative approaches that were already there. There has been a counter-trend, however, that has sometimes masked the increased unity in the life sciences. New fields of specialization, which tend to foster narrowness of training and outlook, continue to develop.

#### The New Curricula

The increased unity within the life sciences has forced the educational system toward a more unified approach to undergraduate education. The classic division between botany and zoology has been broken down at the elementary level, and introductory courses now include important elements from microbiology, biochemistry, physiology, ecology, genetics, and other older and newer administrative and research divisions. A life sciences major now frequently requires a core curriculum of physical sciences, mathematics, and courses in various departments of the life sciences area before complete submergence in one specialty is permitted. If a junior college student intends to transfer to a senior institution, he should be aware of these requirements.

#### The Teacher's Dilemma

The added breadth in curricula creates a problem in the training of those who are to become teachers at the undergraduate level. If the teacher has been trained in one specialty, for example marine ecology, he may have little or no knowledge of another widely divergent specialty in the life sciences, for example biochemical genetics. There would be some question as to this instructor's ability or desire to present a balanced elementary course.

The molecular preoccupation has created the severest problems in biology education. Lack of teacher preparation in the physical sciences leads, in some cases, to abandonment of any attempt to present molecular information; or an attempt is made that is overambitious, unclear, or just plain wrong. On the other hand, there has been a tendency for those with a strong molecular orientation to cover inadequately the higher levels of organization--the cell, organism, and population--and higher functional areas such as behavior.

Research participation, summer institutes, and released time for study are ways for the teacher to increase his versatility, and they should be encouraged and supported. But there is just so much that a normal person can accomplish. One way out of this is through team teaching, but this has some well-known drawbacks. It could, nevertheless, receive more thought, experimentation, and support than it usually gets. One of the reasons for the need for team teaching is the trend to even broader interdisciplinary programs, which require the coordination of teaching over very wide subject areas.

### The Basket Approach

With the interdisciplinary trend well advanced within the life sciences, some institutions are now covering all of the introductory science courses in one comprehensive, integrated sequence required of both majors and non-majors. These programs often follow a conventional basic format using blocks of subject matter from mathematics and the physical sciences before commencing the life sciences. A topic can be presented outside of its usual setting at a point that emphasizes its further application and its broader implications. This makes a great deal of sense to the student who will more willingly follow a sequence dictated by the subject matter rather than an arbitrary, overlapping, or disjointed sequence dictated by the usual departmental and administrative concerns. These courses have received support from those concerned with education in the sciences for the non-science major because the complete program would prevent a student from entirely avoiding major areas in the sciences. The molecular biologists like the courses because every student in the biology sequence has received a controlled prior exposure to the physical sciences.

Core programs and courses are not new in education; they have been tried many times and frequently have failed. The biggest single barrier to success in these programs is in finding the professional and institutional setting that will permit them to function over extended periods. Teachers with attitudes and background that properly mesh can be found to teach the courses, provided their respective departments can release the time and not penalize the participant for efforts outside his immediate specialty. The course should be a more efficient route to basic education than the normal relatively uncoordinated program based on a set of academic regulations and half-hearted, even conflicting, advice.

A serious problem for interdisciplinary courses is coordination. The secret to success is good organization and a good coordinator. This generally means time: A great deal of the coordinator's time is needed for design, meetings with lecturers and laboratory instructors, and for previewing of curricular materials. It is here that some critical support can come from granting agencies: for released time to enable schools to design, staff, and implement interdisciplinary programs.

### Summary

I have tried here to emphasize that a common thread in many specific new approaches in biology education has been a trend toward implementing in educational practice the unity which has taken hold within the existing theory and techniques in the life sciences. This trend should continue, aided by support from the federal government.



## NEW APPROACHES IN THE PHYSICAL SCIENCES IN THE TWO-YEAR COLLEGES

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The most significant new approach related to teaching science in the California junior colleges is the faculty realization that our colleges are open-door, comprehensive, and community in nature. Faculties and administrations are looking anew at courses and curricula to see whether they reflect the education-in-science needs of student bodies characterized by diverse goals, backgrounds, and abilities.

Traditionally, the science faculty of public junior colleges have looked to the major universities and state colleges as the source of all knowledge and wisdom in curricular matters and then, influenced by the pragmatic demands of the local college administrators, they have established courses in chemistry and physics much like those at the four-year institutions. Today, pressures for change are causing a re-examination of these patterns and a searching elsewhere for new goals and plans for curriculum development. Fortunately, new sources have been found, and some new channels of communication have been established. Before considering these pressures and sources, we should look at the open-door, comprehensive, community college characterization more closely.

The term "open-door" means that entry into college is unrestricted. Many courses and curricula are available--some within the range of the student's interests and ability, some outside his interests, and some beyond his ability. He need not choose what lies outside his interest, and he should not be allowed to choose what which clearly lies beyond his ability. The open-door college does not mean an open-door curriculum. It presupposes a variety of curricula to match the potential of a variety of students and the establishment of standards to maintain the integrity of the institution.

The term "comprehensive" means a multiplicity of educational functions or purposes. Junior colleges generally subscribe to five: (1) education for transfer to four-year colleges and universities, (2) education for occupational competence, (3) general education, (4) guidance, and (5) community service.

The "community" concept arises because a college is locally governed, receives the majority of its financial support from local sources, is tuition free, and responds quickly to the educational needs of the community. With an extended day scheduling of classes, the evening enrollment may be larger than the day.

There are six trends or changes which are forcing reconsideration of the structure and content of the chemistry and physics course offerings of the two-year colleges. These are:

The enrollment of a wider variety of students, with diverse

goals, abilities, and backgrounds in our colleges.

2. The better preparation of more freshman students in science and mathematics than previously was the case.
3. The changing nature of the chemistry and physics in lower division science, engineering, and preprofessional courses to prepare students for upper level undergraduate or professional school work. This is forcefully seen by recent curricular changes in four-year colleges and by new textual materials that are being prepared and published.
4. The requirement of industrial and research activities for an increased number of technician-level personnel to assist the professional person in research and development and in production and control.
5. The flood of new information and the many different ways in which this new information is being worked into the college curriculum.
6. The development of modern equipment, making available challenging new experiments and new methods of presentation.

The second significant new approach is the recognition that many two-year college faculty members are outstanding chemistry educators or physics educators and that they are reputable chemists and physicists. This permits faculty members to make contributions and participate in chemistry and physics education activities more than ever before. This recognition has been instrumental in the development of programs for junior college faculty in the various science disciplines. When faculty members from the five types of two-year colleges, the public junior college, the community college, the private junior college, the technical institute, and the two-year center of the university meet to share ideas, experiences, problems, programs, and successes, much is gained.

One such program is now being conducted on a national and regional basis in chemistry. The Two-Year College Chemistry Conference of the Division of Chemical Education, American Chemical Society, brings to the attention of the chemical community and profession the faculty, students, programs, and problems of the two-year colleges. It allows the faculty members from different states and types of colleges to get together to discuss their problems, without domination by the four-year college people. It encourages two-year college chemistry faculty members to get into the mainstream of action and new communication between the junior college faculty member and organizations and foundations interested in the chemistry programs and faculties of the two-year colleges such as the Manufacturing Chemists' Association, the National Science Foundation, the Advisory Council on College Chemistry, and the National Science Teachers Association. The chemists encourage other disciplines to do the same.

I should now like to turn to the consideration of several

specific newer approaches to the teaching of chemistry and physics in our colleges. These approaches involve new courses, new standards for courses, new course content, new laboratory approaches, new curricula, new text materials, and the utilization of some of the newer developments in educational media. I shall try to relate these newer approaches to the five educational functions and the six pressures mentioned earlier. It is not possible, in this short time, to cover the many new approaches existent today, so I have endeavored to select examples which are both significant and representative.

#### Education for Transfer

Several examples are related to the education for transfer function which includes providing a well-rounded lower division education for persons who desire to continue their collegiate education beyond two years. Because many students cannot qualify for admission to the university or state college upon high school graduation, but are capable of obtaining the bachelor's degree, we must provide an opportunity for them to demonstrate their capacity to maintain, over an extended period, an acceptable standard of scholarship in subjects of collegiate level, so that they can enter the four-year institution as fully qualified juniors. Many such students, who are initially ineligible for admission, transfer to and graduate from the four-year college, and continue on to graduate work and higher degrees.

The general chemistry area offers an excellent example of new approaches because there are several associated with this program. First, the changing nature of the course content and better preparation of the freshman students have caused a strengthening of the prerequisites for the course. Students in many colleges now must have a previous course in chemistry with a good grade and have completed three or more years of high school mathematics or equivalent and validate this background on a placement examination.

Second, because of the wide variety of students' abilities and backgrounds, junior colleges are establishing beginning or elementary courses in chemistry to provide the student the opportunity to prepare himself for the general chemistry course. In earlier years and smaller colleges, this was done by having these students enroll in the non-science course. Today, the diversity of student goals and abilities and mathematical backgrounds is so great that the groups have been separated into two courses.

The new content in general chemistry, which was first introduced several years ago, involves a continuation of the shift from a descriptive, inorganic course to a principles course concerned with topics formerly considered in physical chemistry courses. There is greater concern with the relationship between the structure of a substance or particle and the properties of the substance and with the investigation of chemical systems in terms of the thermodynamic and kinetic characteristics. Structures and systems are increasingly being viewed in terms of quantum concepts.

The general chemistry laboratory is being changed. It is moving rapidly toward quantitative experiments demanding student performance that is up to professional standards, with greater emphasis on technique and comprehension, but with a smaller number of experiments being required. Instruments being included in the general chemistry program include the analytical balance, pH meters, spectrophotometers, and chromatographs. There are two distinctive approaches identifiable among junior colleges as they make their general chemistry laboratory more quantitative. One approach introduces the experimental work traditionally found in quantitative analysis into general chemistry. The second investigates chemical systems by making accurate measurements of various physico-chemical properties of the system. The increased use of experiments utilizing unknown samples or requiring answers which are unknown to the student is characteristic of both approaches.

A new approach appearing on the horizon is the development of two courses in general chemistry for science and engineering and closely related majors. There will probably be two different approaches to the differentiation of these courses. One will involve the honors course and regular course approach, while the other will set up one course for physical and biological science majors and some engineers and another for the other students.

The physicists are not being left out of this change. Junior colleges are adopting new approaches to their physics for physical science and engineering majors. These new approaches are being influenced by the better preparation of students, the changes in the mathematics curriculum, and the changing nature of the textual materials being produced for courses such as those at Cal Tech, M.I.T., University of California at Berkeley, and others. These new approaches place more emphasis on the fundamental concepts which form the foundations of contemporary, quantum phenomena, waves and oscillations, and statistical physics, in addition to mechanics, electricity, and thermal physics.

These approaches attempt to convey to the student some of the interest and excitement which the physicist finds in his subject. They stress an understanding of the subject matter in terms of physical and chemical concepts as well as the mathematical analysis. They make strong ties to observable physical and chemical phenomena and they make extensive use of various model forms, to develop an understanding of the concepts in terms of the observed phenomena.

The laboratory involves the use of apparatus capable of making accurate measurements, the introduction of error analysis and statistical experiments, and the imaginative exploration of physical phenomena using electronic equipment. There is some indication that such courses will demand more lecture time and five quarters or four semesters as the minimum, although some of the four-year schools adopting but not developing these approaches, are unwilling to give that much time.

#### Education for Occupational Competence

Perhaps the most dramatic new approaches are found within the scope of the education for occupational competence function.



his includes providing programs which qualify students for employment in an occupation after two years of college, and in programs for workers to upgrade their skills or employment qualifications or to prepare for another category of employment. These curricula lead to the associate degree and/or a certificate of technological competence after two years of full-time study.

The introduction of completely new curricula is the first change which we should mention. Curricula with which the chemistry and physics departments are most directly concerned are those which train semi-professional technicians for research and design activities in support of engineers and scientists. Some manual skills are required, but the major emphasis is on technical knowledge. Many industrial research facilities wish to train technicians in the more specific skills required by the work of their company. These curricula include a balance between the engineering or science and the technician aspect of the program. Technician programs which almost parallel lower division engineering or science curricula result in high attrition rates, too few graduating technicians and general dissatisfaction with the community college's technical education program. When industry wants people for industrial research positions with the type of background found in the transfer program, they hire students from such programs rather than from a technician program.

The semi-professional technician programs generally require one year of technical physics with laboratory, and may or may not require chemistry, depending on the importance of chemistry in the technology. Many colleges are now establishing separate technical physics courses, different from the premedical type general physics, and separate technical chemistry courses, different from the non-science major and general courses.

I would like to discuss the new chemical technology curricula for a moment, because there are two distinctive approaches emerging here. The first approach generally has the student in chemical technology enroll in the same general chemistry, organic chemistry, and quantitative analysis courses as the transfer student, but differentiates from the transfer program in the physics and mathematics required. They also include courses in other technologies and instrumental methods of analysis, and possible industrial chemistry unit operations. They do not include languages. This is generally established where industry wants the students to be able to go on to obtain the baccalaureate degree.

The second approach is the establishment of a curriculum in chemical technology emphasizing the training of career technicians. Students who could be expected to obtain a bachelor's degree are not encouraged to enroll in chemical technology. Instead, students are sought who show determination, who enjoy laboratory work, whose chances of obtaining the bachelor's degree are slight, and who are willing to make work as a technician in the chemical laboratory their career. Science and engineering students who are capable in the laboratory but who cannot handle the rigor and theory of the transfer chemistry, physics, and mathematics courses may transfer to the chemical technology programs.

The chemical technology curriculum includes separate courses in the fields of general chemistry, organic chemistry, analytical chemistry, instrumental methods, industrial analysis, industrial chemistry, introduction to chemical technology, and unit operations. These courses emphasize laboratory work and are taught by members of the chemistry faculty with experience in training and using technicians to assist them in research work in industry. Students are provided with precise directions in great detail for operation of instruments used in experiments.

Another trend involving chemistry and physics and occupational curricula is the establishment of some courses for specific curricula such as nursing, dental assisting, fire science, electronic technology, and the like.

### General Education

Education to develop competence as an individual, as a citizen, and as an effective community leader is included in the general education function. Most junior colleges in California now have at least one such course in chemistry and one in physics.

It is generally accepted that every good chemistry, physics and physical science course must have over-all unity and coherence. Without structure and pattern to hold it together, a course may be difficult to learn and easy to forget and may contribute little to the understanding or appreciation of chemistry or physics. Many of our present courses, especially for the non-science major, can be indicted on two major counts: (1) They deal with many unimportant topics, and (2) they are often a fragmented series of pieces held together only by the glue on the spine of the textbook. One of the most significant new approaches in both the courses for science majors and the non-science majors is the use of themes as the central organizing thread throughout a given course. Such a theme can permit a wide variety of materials to be introduced, all of which can be related to the theme. Examples of such themes in chemistry courses have been chemical systems and chemical bonding and structure. Examples in physics include energy, matter and energy, symmetry, and model making.

A recent Conference on Physics for the Non-Science Major was reported in Newsletter Number 7 of the Commission on College Physics. The reporter spoke thusly regarding the conference view of these courses:

"The single channel, antiseptic, analytical, logical, coldly beautiful, traditional pattern of teaching introductory physics does not communicate to the non-science oriented students. The traditional approach is probably highly efficient for the typical physics major--he furnishes his own internal motivation, and he tends to be happy with and to feel at home with the analytical, mathematical approach. The tendency in the past--happily on its way out--was to simply dilute this hard-boiled physics down to a concentration at which it could just barely be

swallowed by the non-physics science major without rebelling and plough ahead. The conference group was composed almost entirely of people who feel that this approach is no longer adequate . . .

"The most salient feature, by far, of this group of students is the tremendous range of intellectual types. I don't mean IQ. They may all be reasonably smart. But some are verbal, some think abstractly, some can visualize, some could put a carburetor together, some can solve a differential equation but can't say whether a ball will go up or down if you let it loose."

There are three additional topics related to new approaches the physical sciences which should be mentioned. These are (1) utilization of the new textual materials, (2) utilization of some of the new educational media, and (3) research by students and faculty.

Two-year college faculty use the various new textual materials in three ways:

As a primary text with other more conventional texts referred to as sources of questions and problem examples (Students in such situations may tend to become enthusiastic about these new materials since they feel they really learn physics or chemistry from them.)

As enrichment for an otherwise conventional course (Students may gain new insights in the classical physics or chemistry and satisfy their curiosity about relativity or topics in contemporary physics by this approach.)

Instructors may use the new books for preparing lectures in their otherwise conventional courses (Students in this case will not come into direct contact with new textual materials.)

A recent Newsletter of the Commission on College Physics, number 8, calls attention to the importance of keeping in mind that the new materials in existence in physics appear at present to be tantamount to representing an entirely new breed of physics texts, vigorous and exciting, though not yet completely adapted to the environment of the physics courses for which they were intended.

We must realize that the new textual and subject-matter efforts often lack many of the ancillary teaching aids required for harmonious accommodation to the classroom. These aids may include problems of graded difficulty, solved examples, thought-provoking questions, directions for demonstrations or lecture experiments, and laboratory experiments, but teachers wishing to adapt or adopt these new materials may find it necessary to provide tender and time-consuming care during the period of development. In fact it is hoped that many individuals, through using these materials without the appropriate aids, will be stimulated to develop such aids.

The maturation process for the new approaches will be complete only when individuals or groups of chemists or physicists have grafted on to the new materials appropriate teaching aids and

media, because these are essential to the new approaches and because their own understanding and background are not as steeped in the tradition of the new as in the tradition of the old.

The techniques and media which seem appropriate to these new developments and approaches in the physical sciences include the traditional 16 mm motion picture, the 8 mm motion picture including the cartridge forms which fit the Fairchild and Technicolor projectors, video tape, the carousel console in which an audio type is synchronized with 35 mm slides or motion pictures, programed instructional materials, models, and audio tape. We will see a coordinated development of instructional materials using many of these different techniques appearing in the next few years.

### Research

How is research one of the significant new approaches? Consider for a definition of research that of the Wooster Conference on Teaching and Research in Chemistry in the Liberal Arts College, "Research is the application of creative thinking to the solution of any problem." In the November 1964 Junior College Journal, John E. Anderson, President of Columbus College in Georgia, has written an article entitled, "Research in the Junior College--An Anathema or Anodyne?" in which he sets forth the hypothesis that an administrator who discourages research is forfeiting a cure for some chronic problems. Anderson believes that administrators are committing two major errors if they say, "We are interested in teachers, not researchers." The same errors are made by those who actively discourage any research tendencies found in their faculty members and exhort them to spend their time in becoming better teachers; or those who hold the suspicion that the two concepts of research and teaching, if not mutually exclusive, are at least incompatible drives within the same individual. First, he says, they are exhibiting a fundamental misunderstanding of research and, secondly, they are doing a disservice to their institution and ultimately to the taxpayers who support it.

Those pressing problems found in every college can be solved best by the very process that is research, which at first seems waste of time. In the final analysis, Anderson says, "Research be it pure or applied is really a problem-oriented spirit of inquiry, channeled and directed by a rigorous methodology. Through research problems can be definitely stated, relevant data gathered, and meaningful results obtained. This is certainly what the administrator needs as he attempts to respond to the problems besetting him."

The error of doing a disservice to the institution and ultimately to the taxpayers revolves around three foci--students, faculty, and the college. Anderson points out that at the undergraduate level in the four-year college, the spirit of inquiry is fostered in the students. The instructor often acts as a repository of that specific research methodology which is best suited for the particular project under investigation. He notes that humanities, sciences, or business courses emphasize the reading of current professional literature with the attendant language of mathematics



nd statistics. To educate a student in a junior college atmosphere which is foreign, not to say hostile, to research considerations and to expose him to instruction and instructors who are not familiar with or engaging in research is to do him a grave injustice, not only in terms of difficulty of transition to the senior institution environment but also in terms of the self-satisfaction and growth inherent in the completion of research projects.

Administrators contribute an additional difficulty in recruitment of faculty when they deprive the instructor of the opportunity to do creative research. Likewise, the complaint heard from junior college instructors is that the world is passing them by, and their knowledge and subject matter are outdated. This is especially true of science instructors who, perhaps not permitted to do research during the year, are exhorted to return to school or workshops during the summers to keep abreast of their fields. It is a curious inconsistency for administrators to prate against research for nine months and preach for it the other three.

Anderson feels that research will enhance the reputation and esteem of a junior college as an educational institution. The establishment of an atmosphere wherein the faculty contributes proportionately to professional literature, brings outside grant money into the community, and engages in community research and business consulting would provide the leadership which an institution of higher learning should for a community.

In conclusion, I feel there are many new approaches to the teaching of the physical sciences in the two-year colleges, and I have tried to identify some of the more significant ones.

and cytoplasmic convection. Ernest C. Pollard,<sup>1/</sup> at the Pennsylvania State University, has concluded that gravity can account for a difference in the statistical distribution of intracellular particles when these particles get to be about 10 microns or larger in size. His calculations suggest that biological effects can be expected to occur at the level of the nucleolus, so that one could anticipate some changes in enzyme formation and organism development. To study the problem of weightlessness at the cellular level, one needs developing organisms with dimensions of the order of about a millimeter or greater.

Theoretical guidelines like these are valuable in the design of flight experiments. Major practical problems, however, have arisen related to the combined effects of the spacecraft environment. It has been difficult to control all elements of the spacecraft environment so that one can study weightlessness in the classic scientific manner. From the work of the Soviet Union, it appears that some of the cellular effects are related to more than one factor in the environment of space flight. Their data suggest that the combination of the launch acceleration and vibration with radiation and weightlessness may indeed induce changes at the cellular level. A great deal of laboratory work is being done at present to study these changes and to determine which ones are related to weightlessness. A remarkably large number of cellular species have been flown in space, both by the United States and by the Soviet Union, but data interpretation is complex and very little has been established.

My interest in cellular changes related to zero g lies in a NASA-sponsored experiment which Donald Ekberg of my group, in association with Richard W. Price of Colorado State University, is performing which utilizes the amoeba Pelomyxa Carolenensis. It's a giant, averaging a millimeter in size. It has a hundred to a thousand nuclei and is extremely radiation-insensitive. To kill the animal requires the destruction of a large number of its nuclei; and its tolerance, therefore, is approximately  $10^3$  rad. It is planned to study the feeding behavior of the amoeba, its division rate (all the nuclei divide simultaneously) and to examine vacuole formation by electron microscopic and cytochemical methods. The experiment will be flown this fall on the NASA Biosatellite. Our laboratory work at present is primarily concerned with establishing the effects of vibration on the organism so that these effects can be separated from those of weightlessness.

Although the daily radiation dose at the altitude of the orbit to be used for this experiment are low (millirads), it is possible to select organisms that are sensitive to this level of radiation. The lysogenic bacteria (E. coli, K-12) are radio-sensitive in the range of 200 to 400 millirads, and show alterations in induced phage production following exposure to the complex physical environment of space flight. Work is going forward to exploit organisms as radiation detectors, and the Soviets are actively concerned with their use in the study of radio-protective chemicals.

<sup>1/</sup> Pollard, Ernest C. "Theoretical Studies on Living Systems in the Absence of Mechanical Stress." Journal of Theoretical Biology, 8: 113-123, 1965.

## BIOLOGICAL ASPECTS OF THE SPACE PROGRAM

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Space biology and medicine generally lie in the area of ecology, the relationship of the organism to its environment. However, we should be careful to distinguish that in the space context it is the relationship of the organism to the spacecraft environment that is significant, not the relationship to the space environment itself. The engineering task is to tailor a device, the spacecraft and its enclosed environment, in such a way as to protect the organism from the adverse effects of the space environment. Biological problems arise because the weight and power limitations of the spacecraft will not permit us to maintain terrestrial conditions.

Consequently, a great deal of work has been done on determining what kind of departures from the terrestrial environment the organism can tolerate. Early in the manned space flight program, effort was devoted primarily to such considerations as how much can an organism stand in the way of g forces and how can we compromise the atmospheric composition and pressure in order to save weight. These are very practical problems, and human tolerance limits are fairly well known for a whole host of such physiological variables.

There are some elements in the space environment, however, that we cannot easily control without a considerable expenditure in weight, space, power, and money. This is the reason why weightlessness has loomed as one of the central problems in space biology. Weightlessness can be controlled by rotation of the space station, but this is an inordinately complex and expensive procedure. The radiation environment--its composition, how the vehicle wall changes the composition of the radiation, and what effects both the primary and secondary radiation will have on the organism--requires additional study. There is much interest in the so-called circadian rhythms (innate biological rhythms that fluctuate on a daily basis), but we do not know yet their significance for astronaut functions. The astronauts put tinfoil over the windows and make their own 24-hour cycle so that they sleep just as though they were still at Cape Kennedy. The effects of magnetic fields on biological organisms are not well described. The magnetic field of the earth is approximately 0.5 gauss, but both the moon and Mars have very low magnetic fields. Research on the biological effects of both high and extremely low magnetic fields is currently in progress.

### Weightlessness

The site of action of gravity on the biological organism has not been established, and space flight experiments to date have not been really helpful in settling this question. There has been theoretical analysis to determine what this effect might be at the cellular level based upon the distribution of the components of the cell under the combined influence of Brownian motion, gravity,

At the mammalian level, the statement of the weightlessness problem has gradually evolved and has now taken the form of an inquiry into the gravity-dependence of body function. This is a relevant problem for terrestrial life as well as for orbital life. For years it had been taught that gravity is bad, that a man was really meant to be on all fours, and that the consequences of the erect posture are flat feet, pain in the back, and dropping of viscera. The ills that the orthopedic surgeon now takes care of were thought to be related to this awful thing, gravity. However, during the last war, it became apparent that lying down was an equal hazard; and we entered an era in which attention was focused on the problems of bed rest. A number of the complications following surgery or after delivery were shown to be related to recumbency and inactivity. Early ambulation of the surgical patient became common. Some of you may have experienced this treatment and have considered it extremely unpleasant. However, the result has been a remarkable decline in complications.

At the theoretical or experimental level, present work had to do with the effect of recumbency, the results of the attendant inactivity and the relation of these effects to weightlessness. It appears that these effects are very close to those that are anticipated in weightlessness. In weightlessness, of course, the gravitational force is absent, the hydrostatic force has disappeared from the cardiovascular system, and the musculo-skeletal system is unloaded. A certain amount of our daily energy is spent combatting gravity; in weightlessness, this is no longer necessary. In both the best-rest patient and during weightlessness the body adapts to its new physiological state. Many hundreds of normal people have been or are now lying in bed, primarily for the study of the problem of weightlessness and not for the purposes of clinical medicine. Researchers are trying to discover which systems of the body adapt; what is the time course of the adaptation; whether a new steady state is reached; and how one readapts an individual to gravity. In the normal individual the body undergoes changes that are entirely appropriate to the situation. The threat to the individual comes when he re-enters the gravitational field. Those of you who have been in bed for a long time know that if you stand up suddenly you may faint. The astronauts do not faint when they come back from space, but appropriate measurements show that everything is going in the direction of fainting; that is, on a tilt table after flight, men may feel the blood pressure falls, the heart rate is elevated, and the men feel dizzy.

Present research is directed toward the answers to the following questions: "Is it really true that the adaptation to weightlessness is appropriate?" If the adaptation is not appropriate, how can it be prevented?" If adaptation cannot be prevented, can the man be supported adequately on return to earth?"

The adaptations of interest in the cardiovascular system include changes in amount of circulating blood volume and in ability to mobilize reflex resources to prevent drastic falls in blood pressure on exposure to gravity. Adaptations in the musculo-skeletal system include the loss of calcium when the skeleton is unloaded. When the muscular system is unloaded, the muscles may undergo a disuse atrophy.



Investigators are concerned with the development of countermeasures for weightlessness. For instance, what kind and how much exercise should an individual be given to prevent the loss of bone calcium muscular mass? With the Gemini capsule this is particularly difficult because it is about the size of the front seat of a Volkswagen, a pretty confining environment. Researchers are also studying a device called the lower body negative pressure chamber. It permits the application of negative pressure around the lower part of the body to simulate the hydrostatic forces in the vascular system which would normally occur under 1 g.

It is extremely difficult to achieve true zero g for any continuous period in orbit and, consequently, one has to decide what to accept experimentally as a reasonable approximation for biological experiments. The NASA Biosatellite carries the specification that 90 percent of the time the g level will be  $10^{-5}$  g, and 10 percent of the time it may be at  $10^{-4}$  g. This specification indicates the precision with which one must hold the attitude of the spacecraft. Rotation of the spacecraft will generate acceleration around its center of mass. If the specimen happens to be in the periphery of the vehicle, it may experience g's in excess of the specification. This kind of spacecraft stability is a real engineering challenge primarily dictated by a biological requirement.

#### Microbiology

Microbiology is emerging as a specialty of considerable importance in space biology. Several areas have a significant impact on current and future space flight programs, in particular, the relation of microbiology to the closed environment of a space bin, the problem of sterilization of planetary spacecraft, and the detection of extraterrestrial life.

The relationship of microbiology to the spacecraft environment in which man is placed is well illustrated by an experiment conducted by Reyniers<sup>2</sup> some years ago. He put normal rats in a sealed environment, supplied sterile air, sterile water, and sterile food, and then observed what changes took place in the animal, particularly the microflora of its intestinal tract, skin, nose, and rectum. The following events took place: Over the course of the first few weeks, the number of species of organisms, which are tremendous in any living mammal, decreased in number, a process called simplification, so that at the end of a short time, instead of having a profusion of organisms of all kinds, the species were reduced to only a few known types. The system then became what is now called a gnotobiological system. All organisms that were present in the system were known. The consequences of this process were several. The remaining species of organisms were found throughout the intestinal tract, a process known as flooding. In other words, the same organisms would appear in the intestinal tract and in the nose and rectum, where ordinarily different sorts of species survived.

Moreover, the animal may suffer a loss of immunity; that is, as species disappear, the animal's immunity to these organisms

Reyniers, J. A. Lobund Reports, University of Notre Dame Press, 1: 94-95, 1946.

may disappear as well. In certain cases the animal might become overwhelmed with a single species that had overgrown and outstripped all the others. If a specific antibiotic is given, it may be possible to produce a germ-free animal. In animals, loss of bacterial species may also result in altered nutrition. Bacteria in the intestinal tract fabricate certain vitamins. When these bacteria are lost, this vitamin synthesis process is also lost. When the animals were removed from the sealed environment and exposed to other animals in the colony, they acquired a new spectrum of organisms. The usual outcome was that the animal died.

The implications of this research are clear for the space cabin occupants. The source of oxygen in present manned spacecraft is cryogenic or liquid oxygen. In the future it might be acquired from the electrolysis of water. In any case, it is undoubtedly sterile. The water that is supplied to the crew may come from a combination of hydrogen and oxygen formed in a fuel cell, or, if the water is launched with the spacecraft, it is triply distilled, and the whole system is sterile. The food, as well, is very nearly sterile. Synthetic foods, such as Metrecal, are likely to be absolutely sterile. Freeze-dried foods prepared for space flight have an extraordinarily low bacterial count because of the nature of the processing and quality control required.

By analogy the space cabin is very much like the condition in Reynier's experiments and represents a complex problem in ecology. The problem is not academic, as indicated by a 30-day test performed recently at the Boeing Aircraft Company<sup>3/</sup> where many of these conditions pertained. In this manned test the organism of interest that emerged was Shigella, a fairly pathogenic organism. In other similar studies the subjects suffered nausea, diarrhea, and skin rashes, presumably related to this kind of bacteriological problem.

The microbiologist has an important role to play in the sterilization of planetary spacecraft. The requirement for sterilization is based on our desire to attempt the detection of extraterrestrial life. This objective cannot be achieved if instrumentation is contaminated with terrestrial organisms. Likewise, we fail if we seed the planet with organisms and at some future date come back and redetect them. This problem has attracted wide interest in the scientific community.

The present requirement is that the possibility of landing a viable organism on Mars shall be  $10^{-4}$ . This sweeping requirement affects all elements of the engineering task. For instance, the trajectory of the spacecraft for a Mars fly-by mission is determined by the miss distance, and therefore all the guidance and propulsion inaccuracies have to be related to this biological requirement.

The potential for the contamination of Mars is believed to be real. We must expect that Mars will support life until it can be shown to the contrary. Not only must the surfaces of the spacecraft be sterile, but the materials themselves must also be sterile. It is not adequate to sterilize only surfaces; a high velocity impact

<sup>3/</sup> NASA-CR-134. "Manned Environmental System Assessment." Office of Technical Services, Department of Commerce, Washington, D. C. (1961)

will shatter and fragment the spacecraft over a wide area. The requirement that all materials in the spacecraft be sterile means that parts such as transistors must be sterile, an expensive undertaking. For instance, a sterile television tube has been produced, but only some gyros can be sterilized by dry heat; others must be sterilized by radiation. Sterilization cuts across everybody's business. All of the plastics, which we utilize so easily, harbor organisms, and the only way to reach these organisms is with heat. Because electronics will not stand an autoclave, the present solution is dry heat.

In order to achieve sterility, one must reduce the bacterial load on the spacecraft. Thermal death curves are fairly well known for a wide variety of organisms and from these have been selected certain organisms that are quite heat insensitive as test organisms for establishing the time-temperature requirements for dry heat sterilization. Thermal death curves, however, depend upon the initial bacterial load. If the spacecraft is very "dirty," it takes more heat or a longer time than if it is quite clean.

The load reduction process means that the spacecraft must be assembled under ultraclean conditions before the dry heat is applied. My group has been working with the engineers to set up the proper kinds of manufacturing and assembling facilities and procedures so that the use of dry heat will be effective. After sterility is attained, it must be maintained. This is accomplished by encapsulating the vehicle, filling it with a gaseous sterilant, such as ethylene oxide. This barrier must be preserved intact down to the Cape, up on the launch pad, and all during launch to beyond the atmosphere, because the potential for contaminating the spacecraft still exists to 300,000 feet. Many engineers say it can't be done, but the attempt will probably be made.

As for the astronauts, thought has been given to sterilizing the surface of the spacesuit which the man will wear when he goes to the moon and when he comes in, but the process appears highly complicated. Some action has been proposed related to the quarantining of the astronaut as well as quarantining of the specimens upon return to earth. There are two schools of thought. One view favors protection of the astronaut. The other holds that the astronaut could be utilized as the ideal culture material to bring back extraterrestrial life.

The inhospitable nature of the lunar surface and the complexity of the sterilization process has led to abandoning the attempt to produce a sterile spacecraft directed to the moon. Perhaps a number of the Ranger failures were related to the early sterilization attempts. The Soviets have reported that they used both heat and gaseous sterilants for their Venus probe. Although they reported entry into Venus, communications failed and there are no data to show that they really had entered the planetary atmosphere other than trajectory information.

The main attention is now on Mars, and it appears reasonable that we might achieve the objective of sterility for the Mars probes. The Soviets appear motivated in this way, and the new

information exchange relationships established between us have this problem as a central one.

Sterility is a prerequisite for the detection of extra-terrestrial life. A gamut of methods for detecting life on other planets have been proposed and are being studied. Some of these methods present severe problems in sterilization. The proposed methods go from a simple culture device to electronic devices such as the flying spot microscopes to complex physical-chemical methods.

In all of space biology, no other area has excited as much interest as the possibility of detecting extraterrestrial life. The scientific community is particularly attracted to this problem, and the press has given it wide publicity. The social, cultural, and scientific implications are broad.

Dr. Lederberg<sup>4/</sup> has addressed himself to the core of the scientific interest of biologists in the possibility of extraterrestrial life. Simply stated, we have an opportunity to generalize our biological laws. The physicist can claim to universality of laws in the physical realm primarily as the result of the telescope. His observations of the planetary motions and such measurements as the speed of light permit the claim that the controlling laws are not unique to this earth, but are general for the universe. The biologist, on the other hand, has only terrestrial data. In the next 10 to 15 years we can look forward to obtaining another data point and a test of the hypothesis that life as we know it is a universal manifestation, at least in our solar system, or that it is unique to this planet. I can think of no more exciting event in the history of biological science.

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<sup>4/</sup> Lederberg, Joshua. "Exobiology: Experimental Approaches to Life Beyond the Earth." Science in Space, ed. L. V. Berkner and Hugh Odishaw, McGraw-Hill, 1961, p. 407.



**PART II - PROBLEMS OF SCIENCE EDUCATION  
REPORTS OF WORKING GROUPS**

Attendance at the Philadelphia Conference was by invitation only. More than 135 college science instructors from 23 states participated in the conference and assisted in preparing the reports that follow.

Each participant was asked to identify his area of specialization and the group with which he would like to work. In almost every case it was possible to assign participants to the section of their choice. Each person was sent a preliminary report of each of three conferences which had been held at Detroit, Michigan; Tucson, Arizona; and Berkeley, California. Participants were asked to study these reports before attending the Philadelphia meeting and to work with the group of their choice in developing a conference report that would reflect their own thinking, as well as synthesize the reactions of the group reports from other meetings.

The reports that follow will show how effectively the groups carried out their assignments. They are presented with only a minimum of editing, in order to preserve the individuality of each group. It was not the intention of the groups or of the sponsoring organizations to formulate an official position or even to draft recommendations for approval by the NSTA or other organizations. The conclusions and recommendations are nonetheless an important record of thoughtful discussion and sincere effort to analyze present problems and to point the way to positive action for the future. The summary at the end of the reports attempts to bring together some pertinent observations and suggestions for further study.

## GENERAL EDUCATION

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### The Nature and Objectives of General Education Science

Interpretations and understandings concerning the nature of general education science for the non-science major are numerous and varied. These diversifications appear to arise from the multitude of situations, conditions, and requirements that exist in the junior colleges. A synthesis of opinion indicates that foremost is the question: "What should general education science do for the student?"

General education science for the non-science major should enable him to develop certain competencies, such as making observations and the collection and analysis of data in the laboratory (when possible), in the classroom, and in his everyday life. It should assist him in developing appreciation and understanding by its inclusion of the significant philosophical, historical, and cultural elementary of science through the integration of these with the goals of his primary academic interests. It should awaken him to selected principles and concepts of science which are so vital this age of computers, nuclear science, space travel, and cardiac surgery. It should assist the college in attaining its objectives by giving the non-science major a more meaningful realization of science so that he may be a more informed citizen.

A strong trend is apparent in the drift of general education courses away from the traditional surveys of plants and animals in biology and the "watered-down" physics and chemistry offerings of the past. This is concisely stated in a report of a recent Conference on Physics for the Non-Science Major, published in Newsletter of the Commission on College Physics, and cited on pages 22-23 of this report.

Objectives of general education science for non-science majors in the numerous junior colleges are widely diversified. They are dependent upon the objectives of the individual institutions, the course objectives formulated by their faculties, the instructional facilities available, the transfer requirements of home-state universities, the budget, the size of the student body, and the experience, dedication, and background of those involved with the actual classroom instruction. The junior college of small or limited enrollment may find it necessary to offer introductory courses in

science with a two-fold purpose, (1) the initiation of science training for science majors and (2) the accomplishment of their general education mission for non-science majors. Larger institutions frequently find it convenient to separate science and non-science students, but may or may not include laboratory experience in the courses for the latter. Still other junior colleges, finding themselves in liberalized situations, experiment widely with innovations and a constant search for better courses and better methods of presenting them. No attempt was made by this group to evaluate the numerous concepts of the many junior colleges in respect to their science for general education programs or to prescribe any one "type" course or program of science for general education. Rather, a consensus of the group's opinion indicates that if a given program is approaching the objectives outlined for their program and courses, an acceptable degree of success is undoubtedly achieved.

Objectives for science in general education for non-science majors were listed in the Berkeley Conference Report and were approved by the group. These, with some modification are:

To help students see and comprehend the scientific phenomena about them

To show how scientists arrive at their views and to instill in students the means of applying these methods to daily problem solving, questioning, and inquiry

To present the effect of science upon our society

To recognize the basic unity of science by introducing interdisciplinary approaches whenever possible

To show and to develop an appreciation for the esthetic values inherent in the field of science

A second set of similar objectives contained in Guidelines for Science and Mathematics in the Preparation Program of Elementary School Teachers and produced as a joint effort of NASDTEC-AAAS are obtainable from the American Association for the Advancement of Science.

#### How May Courses for Science in General Education be Implemented?

The objectives of an institution for its program of science in general education determine its specific and detailed implementation. Some kind of laboratory experience for the non-science student is recommended by a majority of the group. Experiences in manipulative activities, observation, the collection and interpretation of data, and the scientific reasoning process were indicated as the primary benefits to the student, even though such laboratory experience might involve laboratory activities not usually found in introductory science laboratory courses. Junior colleges unable to provide traditional types of laboratory experiences for students might well experiment with innovations to accomplish equivalent results. Among the alternative avenues for the latter institutions are a variety of approaches including the use of modern audio-visual techniques, including

"close-up" television viewing wherein the critical details of demonstrations and even microscopy may be presented clearly and accurately to large groups of students. The audio-tutorial method which enables students to use initiative and imagination while working at speeds consistent with their abilities has received wide acclaim. Junior colleges which have the capability of developing programs involving this method may anticipate and achieve outstanding success.

What Problems Confront Junior Colleges in Respect to Science for General Education?

1. In respect to faculty, what specific training and background is essential, what should be the faculty member's subject-matter orientation, how may he remain up-to-date academically, and how may he maintain professional association with junior college and senior college colleagues?
2. In respect to facilities, where may junior college science instructors obtain assistance in planning laboratories, classroom and audio-visual aids and assistance in evaluating and selecting equipment?
3. In respect to transfer of students to senior colleges: Should junior colleges pattern their offerings after those of senior colleges to which their students transfer? How may junior colleges communicate and articulate with senior colleges? Should transfer and terminal junior college students be offered courses at the same level or similar courses and different levels of academic quality?
4. In respect to communication, how may junior college faculties maintain liaison?

Recommendations:

1. In respect to faculty: Requirements differ for the selection and certification of junior college faculty, but strong subject matter background with an orientation toward teaching is indicated. Research, however modest, must be encouraged (even if not required) since this medium and the professional association it stimulates are of inestimable value in remaining up-to-date and maintaining contact with colleagues. Faculties must be given freedom in the development of objectives and in the selection of the means of obtaining them.
2. In respect to facilities: Faculties should be consulted early in the planning of facilities within the limits of budgetary considerations and the over-all objectives of the college. Assistance in planning facilities is available through visits to new buildings on nearby campuses, professional societies such as the facilities information service of the American Association of Junior Colleges and vendors of laboratory and audio-visual equipment. Funds spent for adequate and long-range planning of facilities cannot help but achieve successful and lasting results.
3. In respect to transfer of students to senior colleges: Persistence



and continued contact should be maintained with senior colleges in order that junior college programs and courses may achieve smooth and equivalent transfer. Articulation can be successful only if constant and adequate efforts persist.

In respect to communication: Junior college instructors have increased in number to the point where they constitute a major segment of the total of college and university personnel. Media to maintain liaison, cooperation, and communication among them at the instructional level generally are lacking. A recommendation, approved unanimously, indicates the desirability and the need for a publication source to which junior college instructors may refer for the exchange of ideas, information, and the results of experimentation pertaining to science in general education for the non-science major. Since the initiation of a new journal or some form of a newsletter does not seem practical or feasible at this time, space in such journals as the Junior College Journal, or The Science Teacher (the journal of the National Science Teachers Association) should be sought.

In summary, it may be stated that science in general education for the non-science major consists of a core of experiences, principles, and competencies which relate science to daily living which make the student a more informed citizen. The specific details of courses in science in general education are determined primarily by the objectives and goals of the college, the particular interests, backgrounds, and objectives of the participating faculty, the limitations of the college facilities, budget, and enrollments, and the characteristics, goals, and needs of the students being taught.

## PROBLEMS OF TRANSFER STUDENTS

Claude L. Gates, Chairman  
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Clifton T. Odom, Recorder  
Brevard Junior College  
Cocoa, Florida

Richard M. Harbeck, Resource Person  
U. S. Office of Education  
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### General Comments by Chairman

Of the 21 persons attending this discussion group, 13 were from public institutions, and 7 were from private junior colleges. There was only one member in this discussion group who had attended one of the other sessions, either at Berkeley, Tucson, or Detroit.

Of the conferences sponsored up to this time, this was the first discussion group basically concerned with problems of transfer students. Since the majority of the members of the group were new and the topic was new, there was little attempt by the group to deal with the problems in depth. We dealt with only a few problems that came to mind. This is by no means a complete report on all the problems involved in the transfer of students.

It was suggested by a number of participants that at future meetings, groups first divide into private and public institution groups and later reassemble to discuss common problems of both types of institutions.

### Outline of Points Discussed by the Discussion Group

1. On advising students concerning their transfer courses, where can faculty advisors get information on programs relating to four-year curriculum requirements? Further, where can information be obtained concerning the availability of monies, scholarships, etc?

#### Suggested solutions:

- (1) Develop and maintain an up-to-date, centralized library. The library should consist of (a) college catalogs, (b) professional organizations' materials, (c) federal agencies' materials, such as Occupational Outlook Handbook, (d) professional materials, such as Comparative Guide to American Colleges by James Cass and Max Bernbaum; The College Blue Books; American Universities and Colleges by the American Council on Education, etc.
- (2) Professional people in the particular science fields should be consulted.
- (3) Counseling services within the college should be consulted.

- (4) There should be more national, regional, and state conferences, workshops, and institutes on career information for counselors and faculty advisors. Some of these conferences, workshops, and institutes should be sponsored by the junior colleges for junior college personnel.

There is a lack of articulation among junior and senior institutions of higher learning.

Suggested solutions:

- (1) There should be better communication and understanding among administrators of types of institutions of higher learning; both formal and informal communication methods should be used.
- (2) There should be better communication and understanding among science faculties of types of institutions of higher learning, also using both formal and informal methods.
- (3) Everyone associated with the junior college should educate the four-year institutions and the public that the junior colleges are in fact two-year colleges with the responsibility of imparting knowledge at the same level of vigor as the four-year institutions.
- (4) All types of institutions of learning should share course outlines and notify each other of any changes.
- (5) Junior college faculty members should participate in professional organizations and become involved in the solutions of problems germane to both types of institutions.

Senior college and university science faculties seem to feel that the junior college faculties over-rate the academic abilities of their students.

Suggested solutions:

- (1) There should be a measuring instrument instituted that would evaluate the achievement level of students in all lower levels in both junior and senior institutions. Particularly, it should be used at the beginning of the junior year or the end of the sophomore year.
- (2) Junior colleges should make follow-up studies on all transfer students. From results of such studies, comparisons of achievement should be made with the students who did all of their work at the four-year colleges, similar to A National Study of the Transfer Student by Dorothy M. Knoell and Leland L. Medsker.

There appears to be a lack of openings at senior colleges and universities for the average science major student.

Suggested solutions:

- (1) Senior institutions must recognize the problem and

enlarge their present facilities to accommodate more students.

- (2) Senior institutions not now offering science programs should offer science curriculums leading to a baccalaureate degree.
- (3) There should be science branches of senior colleges and universities located on or near junior college campuses.
- (4) There should be better guidance of students at the secondary and the junior college level with regard to transfer information.



## SCIENCE FOR TECHNICIANS

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Newton Junior College  
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Technical programs should consider transfer potential where possible.

A flexible curriculum should be offered to enable those with transfer potential to pursue advanced study with minimum loss of credit. At the same time, those capable of developing occupational competence in a technology should not be eliminated from successful completion of the program because of an attempt to make it a university parallel course. Steps should be taken to change four-year college and university attitude toward the non-acceptance of affiliated two-year college graduates with appropriate transfer credit. University faculty should be invited to two-year colleges to acquaint them with the quality of the course work and to improve methods of communication. Two-year colleges should conduct surveys of the success of transfer students in advanced programs to evaluate the transfer potential of the technical curricula. An effective counseling center and departmental advisory program should be established to aid the student in deciding on transfer or career possibilities.

More effective use should be made of the opportunities offered through the tremendous need for technicians in scientific areas.

Two-year colleges and industry should cooperate in acquainting the public of the professional, financial, and advancement opportunities in employment as technicians.

A concerted advertising effort should be made, using radio, television, and the press toward this end.

Continuing effort should be made in acquainting parents, students, and high school counselors with the professional status of the technician.

The above groups should be made aware of the fact that the responsibilities given to technicians today are similar to those given to engineers ten to twenty years ago. Many students who enroll in bachelor's degree programs fail to realize that the associate degree program may be more effective in preparing them for the career they have in mind.

High school counselors should be invited to conferences at

two-year colleges so they may become aware of the career opportunities in technology.

Programs in technical science can be made more effective.

A course in a technical science must be an ever-evolving, resynthesized one to keep pace with the changing needs of technology and the changing qualifications and capabilities of the students in the program. An outstanding feature of a technical science curriculum is the strength of the laboratory program as an important instructional area. The laboratory should be taught by the professor with careful planning toward programming the instruction with appropriate emphasis on the development of techniques and methods. Laboratory instruction should be up to date, with well-equipped, modern equipment. Laboratory teaching loads should be equated on a par with lecture teaching loads. Each technical curriculum should make effective use of an advisory committee representing the scientific industries.

Each faculty member involved in teaching a technical science should make frequent field visits to become acquainted with the changes in technology. Faculty leaves should be granted to permit field experience to aid in the development of courses of study. To accommodate the need for developing an understanding of theory and principles as well as application, greater use should be made of visual aids. Each college should have an audio-visual director with technicians to aid in the preparation of instructional materials or should be a participating member in an audio-visual center from which such materials would be available. Every technical curriculum should have an appropriate balance of courses in general education to truly educate the student. All science and mathematics departments should willingly design and redesign courses of study to meet the needs of students in technical curricula.

Where high school graduates lack the prerequisites to begin technical curricula, the college should offer appropriate courses in these prerequisites in evening or summer sessions. These colleges should also offer courses in an extension program to retrain industrial personnel.

## PROBLEMS OF STUDENTS WITH POOR BACKGROUNDS

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Mathiston, Mississippi

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Flint (Michigan) Community Junior College

Ethelreda Laughlin, Resource Person  
Cuyahoga Community College  
Cleveland, Ohio

This topic was also mentioned in the Detroit conference, there were special groups who discussed "Students with Poor backgrounds" at both the Tucson and Berkeley meetings. The group the Philadelphia conference represented the areas of biology, chemistry, geology, physics, and physical science. The majority of participants represented colleges with the open-door policy. Discussion centered around the following eleven questions:

Do we have well-defined background requirements in the various areas?

All agreed that an adequate reading level was necessary. One college reported some remedial reading is required if a student scores low on the SCAT test. One college requires that a student be eligible for the regular college English before he can enroll in biology. This was the only college with a specific prerequisite expressed for biology.

All agreed that some math course was a prerequisite for chemistry. Many schools require high school chemistry as a prerequisite for the chemistry course for the various pre-professional students. Many colleges are now requiring that the student validate his high school training by a placement test. Most were using the Toledo Placement Test.

Some colleges require trigonometry in high school or concurrently with the general physics course. Many offer physics concurrently with the second or third semester of a calculus series. Some colleges offer physics only at the sophomore level; therefore, the first year serves as a "weeding out" of the poor students. Some colleges also offer the equivalent of a high school chemistry and physics course on a non-credit basis.

One college has established a "diploma" which can be granted to the student who has taken many hours of remedial or make-up classes but who cannot perform in the regular college courses. Some colleges require that make-up work be done in the summer preceding the fall admission. One college requires summer make-up based on college board scores. The student is permitted to take three classes. If he does not make satisfactory improvement, he is denied fall admission. About 50 out of 300 are required to take this work.

2. Can we identify the student with ability and poor background?

Many schools have a cutoff point established for some standard tests such as SCAT or ACT. It was pointed out that we must be flexible enough to consider the student who scores poorly but is recommended by the high school counselor. The group reported varying experiences. Some members felt they could not rely on counselors' recommendations; some felt that they could. Perhaps it depends upon the local situation, and the college should attempt to work closely with the high school.

3. What remedial courses are needed for the student with ability but a poor background?

It was agreed that English and mathematics are the two important basic skills. Many students with ability need help in learning to read with comprehension at a high rate of speed. One college has developed a learning laboratory. The student works at his own pace on reading, writing, and arithmetic; however, this is concurrent with his college program which may be reduced because he is scheduled for considerable time in the laboratory.

It was agreed that reading is the most important skill needed by all students. In mathematics, fractions, decimals, exponents, and radicals seem to cause the most trouble.

In a discussion of grade requirements in order for a student to move to the next higher course, it was agreed that a course in the transfer program require the minimum of a "C" grade in sequence courses.

4. What new techniques in teaching have been tried or are being tried now?

One new college is planning to do most of the teaching through programmed instruction. It is presently using commercially available programs, but plans to write its own programs. One college reported using TV as another means of reinforcement and found that color TV seems to get more attention from the student. However, if the TV is made optional, few students take advantage of the material.

Some colleges are using the CHEMS films, which are available in cartridge form and, thus, are easy for students to use. These can be used with a pretest, study outline, and then a post-test. El Camino Junior College is carrying on such a project.

It was mentioned that Bell Telephone Company has some very good films in physics and genetics and that film loops or single-concept films are being used. It was agreed that a film evaluation source for films at the college level would be very helpful.

5. Is a physical science course a good approach to the correction of deficient backgrounds?



Most participants felt that physical science courses are designed to stress concepts of the physical sciences for the non-science major and that this was not a remedial or repair approach.

One college reported that it was trying an intradisciplinary approach in which it was attempting to help the student realize that English writing was for science as well as for English class and that math was important and useful out of the math room.

What is the responsibility of the science area to the student with poor ability?

A number were against offering low-level courses but felt that we must recognize that this student will be a terminal student and offer him as much as possible, but not teach high school-level courses. However, many of the participants favored a several-track program for the college and placement of the student according to his ability.

Can we successfully establish tracks for students, and should there be a track which has no science requirement?

It was agreed that a college transfer science program and a terminal program can exist side by side. It may also be necessary to have a vocational or career type science program; this will depend upon the philosophy of the particular college. The terminal and career courses should not be lower level but should be courses especially designed for a particular set of students.

We should realize that it frequently takes time for a student to get on the correct track; it should be easy for a student to transfer from one track to another. We must keep in mind that parental pressure often forces a student to attempt something beyond his ability.

It was agreed that good guidance is needed as early as the junior high school level. Guidance counselors should be made aware of the requirements for all programs. Many seem to realize that math is needed for transfer college science programs but do not advise career students to study as much math as possible.

It was agreed that a good terminal science course for non-science majors could be based upon the history and philosophy of science.

The next topic for discussion centered around the need for greater liaison between the guidance and science departments.

It was agreed that at least one science instructor should receive released time to serve as a coordinator for science advisement. The group felt that science advisement should be available for evening students.

The group also discussed class loads for instructors and felt strongly that laboratory hours should be counted on a one-to-one relationship.

9. The question was raised about the evaluation of the success of students in the lower-track science courses.

It was agreed that transfer and terminal (non-science) courses are evaluated by the senior colleges and that industry evaluates the career courses.

The group felt that both essay and objective tests should be used in testing progress in a course. Students with poor backgrounds would probably receive the most help, if their writing mechanics could be checked. They usually need to be made aware that writing skills are needed in science classes. Most of the group members agreed that deduction of points for errors in writing did cause the student to take more interest in these matters.

10. Does the actual schedule of classes have an effect on the success of the poorly prepared student?

It was generally agreed that these students should be scheduled with some breaks between classes regardless of the student's wishes. He cannot perform best if he takes four classes in a row and has no break.

It was also mentioned that some of these students with backgrounds are a result of a cultural deprivation. This may occur in large urban cities or small, fairly isolated communities. Perhaps interdisciplinary courses are a partial answer to the problem.

11. Should colleges establish courses to meet special needs of industry?

In the keynote address, J. O. Luck, Head, Education and Training, Murray Hill (New Jersey) Laboratory, Bell Telephone Company, stated that he did not think that colleges should set up particular programs or courses to satisfy a particular industry. The majority of the group felt that a college should establish a program or course if there was a local need and industry could absorb all of the graduates of the program. Industry should make clear the area of content and serve as an advisor, but the details of content should be established by the college faculty. This is no different from that which is done for nursing and programs for dental assistants.

If there is a need for a particular course so that students can upgrade themselves in a particular industry, the science department should attempt to make the course available; but the college should accept advice, and the college staff should direct the content of the course.

Summary of pertinent points:

The student with poor background and good ability and the student with poor background and poor ability should be identified.

Remedial reading, writing, and arithmetic should be established. Remedial courses should be completed before the college courses are pursued. Courses in speed reading may be needed by well-prepared students.

Several tracks should be established. Science courses should be offered for transfer students, for terminal (non-science majors), and for career (vocational) students. These courses should have clearly defined objectives and be planned to meet the needs of a specific group of students.

A science instructor should receive released time to work on guidance for students in the science area. There should be a close liaison between junior high and senior high school for guidance in the science area.

Laboratory hours should be counted on a one-to-one basis in determining the faculty load.

We should study the use of new techniques such as programmed instruction and intradisciplinary courses in all phases of teaching but particularly for the remedial courses.

There is a need for a good source for film evaluation at the college level.

Physical science courses are not designed for remedial work but, rather, for the non-science major.

Colleges should establish programs or courses required by a particular industry, but the college faculty should determine the content with advice from the industry.

Students with poor backgrounds should be scheduled so that all classes are not consecutive, but that the students have frequent breaks for best performance.

The question raised at the general summary meeting should be considered: Should we have the same entrance requirements for the older, more mature student in the science area?

## LABORATORY FOR THE BIOLOGICAL SCIENCES

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### The General Biology Course

The aims of the general biology course for liberal arts and biology transfer students (biology majors) are the same. Because of different student backgrounds and deficiencies in preparation, it may be necessary to give separate courses. It was the opinion of most members of the group that the terminal nursing program requirements are so specific at present that they often require a special course for the program. Where the existing biology course fulfills the nursing requirements, it is recommended that the nurse take the regular course.

The subject of teaching general biology rather than botany and zoology was discussed. General biology is taught in approximately 50 percent of the schools represented by the group. In four schools, a one-semester course in cell biology is followed by botany and/or zoology.

An honors course in biology was strongly recommended. It should be prerequisites--one previous year of biology with a "B" grade was suggested. Some advanced honors courses are seminar type which carry variable credit.

### Laboratory Requirement for All Biological Sciences

The group strongly endorsed a laboratory for all biology courses. The majority feels that there is better laboratory learning where the laboratory is integrated with the lectures. The open-ended laboratory investigation was recommended, particularly for the better student.

There should be no more than 20 students in any laboratory section.

### Emphasis on Molecular Biology

It was felt that liberal arts and terminal students need less emphasis on molecular biology than does the biology major. Where background deficiencies exist, some preliminary chemistry is given as part of the biology course. Students with good high school preparation might be placed in an advanced course on the basis of



ir performance on a placement test.

#### Audio-visual Aids, Programed Instruction, Audio-tutorial Programs

The instructor should choose the type of audio-visual materials he wishes to use in conjunction with laboratory work. The use of tapes and modified programed instruction can be profitable for student make-up and review.

The audio-tutorial method is a highly structured approach which may not necessarily be a more economical way of presentation for large numbers of students in contrast to the more traditional laboratory work. It provides for efficient, independent work where time and space considerations permit.

#### Working Load

Equal credit should be given for lecture and laboratory work, hour for hour, in determination of the instructor's schedule. In addition to the limit in clock hours, consideration should be given to the number of preparations, administrative duties, etc., and extra reimbursement should be given for extra hours. A total of twelve contact hours is recommended, with fifteen as maximum.

#### Biology Laboratory Facilities

The biology faculty should be consulted in regard to planning laboratory space. There should be prior consultation with the architect, and final approval should be the responsibility of the faculty involved. The long-range program should be considered when plans are made so that a maximum of flexibility is allowed. Separate laboratories for advanced courses are recommended. Animal rooms and a greenhouse are considered necessary. These should be adequately supervised.

It is recommended that periodicals and appropriate reference books be kept in the laboratory for student use; it has been shown that there is less book loss and more student use when these materials are in the laboratory. Reprints may also be used in this way. There should be duplicates of these materials in the library.

#### Laboratory Assistants

Laboratory assistants are necessary and should be well prepared. These assistants might include both student aides and instructional and technical assistants. They should not be considered replacement for adequate teaching faculty. The number of assistants should be adequate for the number of faculty and the number of students in the laboratory.

## LABORATORY FOR THE PHYSICAL SCIENCES

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Laboratory work is a vital part of any science course. But the non-science major especially needs a kind of laboratory experience different from that of most current courses. He needs to think his way through and to appreciate the great concepts of science; he should know how these concepts evolved and were tested.

Such a course should:

1. Use an interdisciplinary approach
2. Follow the historical development of the concepts of science
3. Be based on extended laboratory projects of three to five weeks each
4. Use projects which have a quantitative basis
5. Guide the student through the methodology of science in his investigations
6. Consider in depth the important conceptual schemes of science
7. Present science as a stimulating subject, intellectually satisfying, and significantly related to life experiences

The laboratory project need not require great technical skill or expensive equipment. It should be organized over a subject matter area and be of the "open-end" type. Flexibility is needed both for the time available for the project and for the specific kind of experimental work to be done. Application of appropriate graphic techniques can simplify the mathematics used. (One reference for such projects is The Laboratory Approach to the Physical Sciences by C. E. Ronneberg, et al, Houghton Mifflin, New York. 1965. 157 pp.)

This broad approach to laboratory work, with its emphasis on student involvement with scientific concepts rather than on detailed laboratory workbook procedures, should be even more effective in the regular physics and chemistry courses for science majors. It is recommended that such an approach be tried in these classes.

Another topic discussed was that of the use of complicated

truments and special techniques in advanced courses. It was  
eed that the "black box" approach should be avoided.

The comparative value of teaching descriptive chemistry  
cts) vs. theory was discussed. It soon became apparent that no  
ber of the discussion group held that either descriptive chem-  
ry or theoretical chemistry alone was of much value. Rather,  
is important to use the facts of chemistry to develop the  
ories of chemistry so that the student will understand the con-  
ts of chemistry. This idea was extended as the multilevels of  
entific concepts: facts at the lowest level, methods added at  
intermediate level, and principles and philosophy included on  
upper level.

This group also considered how the teacher might be able  
find time to make these improvements in laboratory teaching.  
recommendations received emphatic support:

For teaching-load computation, one hour of laboratory should  
equal one hour of lecture.

Enough paid clerical and laboratory technical help should be  
available so that the science teacher is free to spend his  
time teaching.

## CONCLUSIONS

There are several areas of agreement among the various sessions that should be considered significant in planning science programs. There was almost unanimous agreement among the participants that:

1. Science cannot be taught effectively without laboratory work. This work should not follow the traditional "cookbook" experiments so commonly found in laboratory manuals. It should represent new, imaginative, open-ended experiments that will challenge the students to think and help them to understand what science is really like.
2. Laboratory work, properly conducted, is as demanding on the instructor's time as are lecture sessions. Work load should be computed on a clock-hour, rather than a credit-hour basis. As it is important that instructors be provided adequate laboratory assistants to supplement, but not to replace the instructor's responsibilities.
3. There is an increasing need for emphasis on principles, rather than on facts. Individual bits of information should be used as a means to the end of making generalizations and understanding principles, and not as an end in themselves.
4. There is a need for constant course revision and improvement. No one course can be considered acceptable for every institution, and instructors should be encouraged to develop new and imaginative courses that reflect their particular capabilities and yet provide an adequate understanding of science. This is particularly essential for general education courses, which have generally been unimaginative and unsatisfactory. In spite of all daydreams to the contrary, there is no probability of discovering an ideal course of study that can be adopted as a permanent part of the curriculum of any institution.

Junior college science instructors appear to be willing and active in developing new programs and updating content. These activities should provide a stimulus for instructors in four-year colleges and universities to expend more effort to modernize their curriculum so that the two-year colleges will not find themselves hampered in their progress by outmoded restrictions in the senior institutions. There is some evidence that efforts on the part of junior colleges to meet the requirements of four-year institutions may be hampering change. For example, in spite of the general agreement on the value of consolidating traditional courses in biology, some schools still feel compelled to retain the traditional zoology-botany approach.

Junior college instructors appear to reflect much more concern for the individual student than do instructors in some four-year institutions. The attitude of the junior college instructor seems to be "let's do our best to give the students a chance" instead of "let's flunk out the low achievers and get rid of them."

There is a reassuring evidence of the competence and professional attitude of the junior college instructor. The two-year college is here to stay, and the percentage of underclassmen who will get their education in these institutions will continue to increase. The quality of the junior college provides a challenge to four-year colleges and universities to work harder to maintain their role of leadership in higher education.

There was pervasive evidence of the need to provide two-year college science instructors with better means of communication and more opportunity to discuss mutual problems. The National Science Teachers Association is trying to determine what it can do to serve this group more effectively. As a part of this effort, NSTA is planning to hold more conferences in various sections of the country to provide the opportunity for more interchange of ideas. If you are interested in attending some of these conferences, you can obtain further information by writing to the National Science Teachers Association, 1201 Sixteenth Street, N. W., Washington, D. C. 20036.